

Application No.: 10/511,986
Amendment under 37 CFR 1.111
Reply to Office Action dated February 23, 2007
May 21, 2007

AMENDMENT TO THE SPECIFICATION

Please substitute the heading beginning on page 1, line 2 and ending at line 2 as follows:

-- BACKGROUND OF INVENTION

1. Field of the Invention --

Please substitute the heading beginning on page 1, line 7 and ending at line 7 as follows:

-- 2. Discussion of the Related Art --

Please substitute the paragraph beginning on page 1, line 8 and ending at page 1, line 16 as follows:

-- Bonding objects to each other, for example, a mounting method for approaching a chip to a substrate at a condition of face down and bonding both objects to each other by pressing electrodes of the chip and the substrate to each other (as needed, accompanying accompanied with heating) is well known.

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Further, a method is also well known wherein, at the time of such a mounting, the mounting part is enclosed by surrounding it by a chamber, after the inside of the chamber is set at a specified atmosphere and various treatments are carried out, or after the pressure in the chamber is reduced and the inside of the chamber is set at a predetermined vacuum condition, the mounting is carried out. --

Please substitute the heading beginning on page 2, line 2 and ending at line 2 as follows:

-- SUMMARY OF THE INVENTION --

Please substitute the paragraph beginning on page 2, line 3 and ending at page 2, line 10 as follows:

-- Accordingly, an object of the present invention is to provide a mounting method and a mounting device which can realize a local chamber structure capable of locally and efficiently enclosing a bonding part and its vicinity from surroundings and adequately varying the shape of the enclosed space interlockingly with the bonding operation while

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maintaining the enclosed condition even at the time of bonding,
~~and which.~~ This method and device can quickly and easily
achieving achieve a predetermined vacuum degree or specified-gas
atmosphere by a small device using the local chamber structure,
thereby they easily and inexpensively satisfying satisfy various
required treatment conditions or mounting conditions. --

Please substitute the paragraph beginning on page 2, line 21
and ending at page 4, line 11 as follows:

-- In this mounting method, although the mounting step
~~accompanying~~ accompanying the bonding operation can be started
immediately after the above-described step for setting a
predetermined vacuum condition, various treatment steps or a
step for setting various conditions can also be interposed
before starting the mounting step. --

Please substitute the paragraph beginning on page 3, line 5
and ending at page 3, line 14 as follows:

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-- In this case, the cleaning by the energy wave or energy particle beam can be carried out under the predetermined vacuum condition. Further, a method can also be employed wherein the cleaning by the energy wave or energy particle beam is carried out after reducing the pressure in the local chamber to set the inside of the local chamber at the predetermined vacuum condition, and after the cleaning and before the bonding, the inside atmosphere of the local chamber is replaced with an atmospheric inert or oxidizing gas. Although a plasma, an ion beam, an atomic beam, a radical beam or a laser can be used as the energy wave or energy particle beam, in particular, it is preferred to use a plasma from the viewpoint of its easy handling, device cost and simple structure. --

Please substitute the heading beginning on page 7, line 14 and ending at line 14 as follows:

-- BRIEF DESCRIPTION OF THE DRAWINGS --

Please substitute the heading beginning on page 8, line 3 and ending at line 3 as follows:

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-- DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS --

Please substitute the paragraph beginning on page 8, line 6 and ending at page 15, line 21 as follows:

-- Fig. 1 shows a mounting device 1 according to an embodiment of the present invention. In Fig. 1, as objects facing each other with a gap, a case is exemplified where one object is a chip 2 and the other object is a substrate 3. A plurality of bumps 4 (in Fig. 1, two bumps 4 are shown) are provided on the chip 2, and corresponding pads 5 (for example, electrodes) are provided on the substrate 3. [[Chip]] The chip 2 is held by a chip holding means 6 provided as one object holding means, and the substrate 3 is held by a substrate holding means 7 provided as the other object holding means. In this embodiment, the chip holding means 6 can be adjusted in position in Z direction (in a vertical direction), and the substrate holding means 7 can be adjusted in position in X, Y directions (a horizontal direction) and/or in a rotational direction (θ direction).

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Where, the chip 2 means any object with any form being bonded to [[a]] the substrate 3 regardless the kind and size, such as an IC chip, a semiconductor chip, an optoelectronic element, a surface mounting part and a wafer. [[Bump]] The bump 4 means any kind of bump being bonded to the pad 5 provided on the substrate 3, such as a solder bump and a stud bump. Further, the substrate 3 means any object with any form being bonded to the chip 2 regardless the kind and size, such as a resin substrate, a glass substrate, a film substrate, a chip and a wafer.

[[Pad]] The pad 5 means any kind of pad being bonded to the bump 4 provided on the chip 2, such as an electrode accompanying with electric wires, a dummy electrode accompanying with no electric wire, etc.

Further, in this embodiment, the part of the chip holding means 6 directly holding the chip 2 and the part of the substrate holding means 7 directly holding the substrate 3 are constructed as electrode tools 8 and 9 capable of functioning as electrodes for generating a plasma, respectively, and a heater is incorporated thereinto, the objects can be heated via at least one electrode tool, an electrostatic chucking means is incorporated thereinto, and

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at least one object can be held electrostatically.

Although the heater and the electrostatic chucking means are not shown in the figure, known means can be used as both of them. In Fig. 1, the label 10a shows an electrode terminal for an electrostatic chuck incorporated into the side of the substrate holding means 7, the label 11a shows a terminal for a plasma electrode, and the label 12a shows a terminal for a heater, respectively, and electricity is supplied through an electrode connector 13. As the order pattern, it is preferred that an electrostatic chuck, a plasma electrode and a heater are disposed in order from the surface layer. Similarly, the label 10b shows an electrode terminal for an electrostatic chuck incorporated into the side of chip holding means 6, the label 11b shows a terminal for a plasma electrode, and the label 12b shows a terminal for a heater, respectively.

Around both objects 2 and 3, provided is a movable wall 15 capable of moving until coming into contact with one object holding means (in this embodiment, chip holding means 6) to form a local chamber structure (a local chamber 14 is shown by the two-dot chain line in Fig. 1) having a local enclosed space for enclosing both objects in the

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local chamber, and capable of moving in a direction for reducing the volume of the local chamber 14 (in this embodiment, a downward moving direction) following the movement of the object holding means (in this embodiment, chip holding means 6). This movable wall 15 is formed in a cylindrical rigid structure, and it can be moved vertically in Fig. 1 by a cylinder means 19 having a movable wall lifting port 16, a movable wall lowering port 17 and an inside sealing mechanism 18. A seal member 20 capable of being elastically deformed is provided at a tip of movable wall 15, and at the above-described contact condition, the inside of the local chamber 14 can be sealed and enclosed against the outside more surely.

In the side of the substrate holding means 7, a vacuum pump 21 is connected to the local chamber 14 thus constructed, as a vacuum suction means for reducing the pressure in the local chamber 14 to set the inside of the local chamber 14 at a predetermined vacuum condition. The air or gas in the local chamber 14 is sucked by the vacuum pump 21 through a suction passage 22. Further, separately from this suction passage 22 or together with this suction passage 22, a gas supply passage 23 for supplying a

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specified gas such as an argon gas (Ar gas) into the local chamber 14 is provided in the side of the substrate holding means 7.

Using the mounting device 1 thus constructed, the mounting method according to the present invention can be carried out in the following various embodiments. Typical examples will be shown in Figs. 2 to 5.

First, in the mounting method according to a first example shown in Fig. 2, at the object setting step, the chip 2 is held on the side of the chip holding means 6 and the substrate 3 is held on the side of the substrate holding means 7. Next, at the alignment step, a recognition means 24 (for example, a recognition means having two sights of an upper sight and a lower sight) is inserted between both objects 2 and 3, the upper and lower recognition marks for positioning are read, and based on the read information, the substrate holding means 7 is adjusted in X and Y directions, and further, as needed, in θ direction, to control the relative positional relationship between both objects 2 and 3 within a predetermined accuracy range.

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After the alignment, a pressure for the lifting movement of the movable wall 15 is supplied to the cylinder means 19 though the movable wall lifting port 16, and the movable wall 15 is moved until the tip of the movable wall 15 is brought into contact with the lower surface of the chip holding means 6. By this, a local chamber 14 substantially enclosed from surroundings is formed, and both objects 2 and 3 are enclosed in this local enclosed space. By sucking by the vacuum pump 21 through the suction passage 22 at the condition formed with the local chamber 14, the pressure in the local chamber 14 is reduced (vacuum sucked), and the inside of the local chamber 14 is set at a predetermined vacuum condition. As the predetermined vacuum condition, for example, a vacuum degree of 130×10^{-1} Pa or less is employed. Because an electrostatic chuck is used for the chip 2 or the substrate 3, even if the condition is set at a high vacuum degree, the object holding state can be maintained with no problem. In a case where this vacuum degree in the local chamber 14 is maintained after this step, by keeping the contact force of the movable wall 15 to the chip holding means 6 at a proper strength, the inside of the local chamber 14 can be surely sealed from

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the outside and the inside can be maintained at the predetermined vacuum condition.

Next, the surfaces being bonded of the objects are cleaned by an energy wave or energy particle beam. Although this cleaning can be carried out even in the above-described high-vacuum state, because a plasma is used as the energy wave or energy particle beam in this example, in . In order to generate the plasma efficiently and easily, a required amount of Ar gas is supplied into the local chamber 14 through the gas supply passage 23 after the pressure in the local chamber 14 is reduced to set the inside of the local chamber 14 at the predetermined vacuum degree, and the inside atmosphere of the local chamber 14 is replaced with Ar gas while the inside of the local chamber 14 is maintained at the predetermined vacuum degree.

At this state, in the local chamber 14, a plasma is generated between the upper and lower electrodes (electrode tools 8 and 9), and the surfaces being bonded are cleaned by removing organic substances and foreign materials on the surfaces of the objects by the generated plasma. By this cleaning, the surfaces being bonded are activated. In this

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plasma cleaning under the Ar gas atmosphere, the irradiation direction of the plasma can be switched alternately by switching the polarities of the upper and lower electrodes alternately, and it becomes possible to efficiently clean both surfaces being bonded [[of]] to the chip 2 side and the substrate 3 side.

Next, the chip 2 and the substrate 3, whose bonding surfaces have been activated by the above-described plasma cleaning, are bonded to each other. In the bonding step, although the chip holding means 6 is moved down and following the movement of the movable wall 15 in contact with the chip holding means 6 is also moved down, during this movement, because the movable wall 15 is always maintained at a condition being brought into contact with the lower surface of the chip holding means 6, the good enclosed state of the inside of the local chamber 14 can be maintained as it is although the volume of the local chamber 14 is reduced. At that time, if a force acting to the chip holding means 6 by the pressure in the local chamber 14 (vacuum pressure) (a force for moving the chip holding means 6 down) and a contact force of the movable wall 15 to the chip holding means 6 are controlled at a

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constant relationship, the moving-down force of the chip holding means 6 can be suppressed small, and the control of a pressing force for bonding due to the chip holding means 6 after the contact of the chip 2 with the substrate 3 is facilitated.

Further, if a force acting to the chip holding means 6 by the pressure in the local chamber 14 (vacuum pressure) (a force for moving the chip holding means 6 down) and a contact force of the movable wall 15 to the chip holding means 6 are substantially balanced, in a case where the head has a cantilever structure, a moment is not generated, it is advantageous on parallelism and positional accuracy. Where, "substantially balanced" means that there is no problem even if there is a slight difference between vertical forces, because the axis of vertical movement can be maintained. Further, even at the balanced state, because the contact force does not vary, the good sealing condition can be maintained as it is.

Bumps The bumps 4 of the chip 2 and the pads 5 of the substrate 3 are brought into contact with each other and bonded to each other. Since both surfaces have been activated by the aforementioned plasma cleaning and organic

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substances and oxides have been removed from the bonding surfaces, a room temperature bonding in vacuum condition becomes possible.

Fig. 3 shows a mounting method according to a second example. In this example, the process from the setting of the objects to the plasma cleaning under Ar gas atmosphere condition accompanied with switching of electrodes is substantially the same as that of the first example shown in Fig. 2. In this second example, after the plasma cleaning under Ar gas atmosphere condition and under the predetermined vacuum condition accompanied with switching of electrodes is performed, Ar gas is further supplied into the local chamber 14 through the gas supply passage 23, ~~the~~ . The inside of the local chamber 14 is replaced with an atmospheric Ar gas (an atmospheric inert gas). Further, associated with that, the pressure of the movable wall lifting port is lowered down to a degree capable of maintaining the sealing.

Then, at the condition of the atmospheric Ar gas atmosphere, the chip holding means 6 is moved down, following this movement of the movable wall 15 in contact with the chip holding means 6 is also moved down, and the bumps 4 of the

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chip 2 and the pads 5 of the substrate 3 are bonded to each other by pressing. Under the aforementioned vacuum condition, because a pressure is applied at a sealing portion of the movable wall, in a case where a slight inclination exists on the upper and lower holding means, there is a possibility that a moment generates and a positional shift in mounting at several-micron order may occur. However, if the atmosphere is returned to an atmospheric pressure condition and thereafter the mounting is carried out, such a moment is not generated, and a higher accuracy mounting can be performed. At that time, in this embodiment, the bonding is carried out further accompanying heating. The heating can be carried out by the aforementioned incorporated heater. In this bonding step, because the bonding surfaces of the chip 2 and the substrate 3 are activated by the plasma cleaning under Ar gas atmosphere condition at the prior step, a desirable bonding can be performed by a relatively low-temperature heating. Namely, a required metal bonding between the bumps 4 of the chip 2 and the pads 5 of the substrate 3 can be achieved by a low-temperature heating.

Fig. 4 shows a mounting method according to a third example. In this example, at the step of setting the

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objects, or at the step of alignment, a sealing material 31 (in this example, a non-conductive paste (NCP)) is applied onto the surface being bonded of one object (in this example, substrate 3), and after the alignment, the local chamber 14 is formed by lifting the movable wall [[14]] 15, and the inside thereof is vacuum sucked. At this step, first, air contained in the paste is deaerated. The inside of the local chamber 14 is set at a predetermined vacuum condition, the chip holding means 6 and the movable wall 15 are moved down, and the bumps 4 of the chip 2 are pressed onto the pads 5 of the substrate 3. At that time, although the sealing material 31 having been applied is expanded toward outside, because the sealing material 31 flows under the predetermined vacuum condition, residual air can be suppressed. Then, at the same time, or immediately after this step, the bumps 4 of the chip 2 and the pads 5 of the substrate 3 are bonded to each other accompanying heating, and at the same time, the sealing material 31 is cured. If air remains at this time of curing the sealing material 31, there is a fear that it remains at the form of voids by the increase of the volume due to the heating, but, because of a heat bonding under the

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predetermined vacuum condition, a voidless bonding becomes possible.

Fig. 5 shows a mounting method according to a fourth example. In this example, solder ball bumps 4a capable of being heat-melting bonded are provided as the bumps of the chip 2. In this example, the process from the step of setting the objects to the step of vacuum suction is substantially the same as that of the first example shown in Fig. 2. In this fourth example, after the inside of the local chamber 14 is set at a predetermined vacuum condition, the inside of the local chamber 14 is replaced with an atmosphere of a specified gas. In this example, a non-oxidizing gas, especially, a nitrogen gas (N₂ gas) with an atmospheric pressure is used as the specified gas.

After the inside of the local chamber 14 is replaced with the atmospheric nitrogen gas, the chip holding means 6 and the movable wall 15 are moved down, the solder ball bumps 4a of the chip 2 are pressed onto the pads 5 of the substrate 3, and they are heat bonded. Because of heat bonding in the nitrogen gas atmosphere, a secondary oxidation ascribed to heating can be suppressed, and at a

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fluxless condition, the bumps 4a and the pads 5 can be bonded at a high reliability.

As shown in Figs. 2 to 5, in the present invention, various conditions can be employed for the mounting formation. In any formation, the local chamber 14 can be efficiently formed by the vertical movement of the movable wall 15, ~~and since~~. Since the movable wall 15 is vertically moved by the cylinder means 19, it can be moved down following the movement of the chip holding means 6 and a target atmosphere in the local chamber 14 can be maintained even at the time of bonding operation, a reliable bonding state can be achieved.

Thus, in the mounting method and the mounting device according to the present invention, since a local chamber is efficiently and easily formed by a movable wall, and after the step for setting the inside of the local chamber at a predetermined vacuum condition, the object holding means and the movable wall are moved in a direction decreasing the volume of the local chamber while the inside of the local chamber is set at a target atmosphere and the state is maintained, ~~and~~. Therefore, a desirable bonding

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can be performed, and a reliable bonding state can be efficiently obtained by a small device. --

Please substitute the heading beginning on page 17, line 1 and ending at line 1 as follows:

-- What is claimed is: --

Please substitute the heading beginning on page 22, line 1 and ending at line 1 as follows:

-- ABSTRACT OF THE DISCLOSURE: --

Please substitute the paragraph beginning on page 22, line 2 and ending at line 12 as follows:

-- A ~~mounting method and a mounting device, the mounting~~ method comprising includes the steps of, after positioning objects being bonded relative to each other, moving a movable wall positioned therearound until coming into contact with one object holding means to form a local chamber having a local enclosed space, enclosing both objects in the chamber, reducing

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the pressure in the chamber, moving the object holding means in a direction for reducing the volume of the chamber and moving the movable wall following the movement of the object holding means, and bonding both objects to each other by pressing,
~~whereby, since . Since the part to be bonded bonding part and~~
~~[[its]] the vicinity of the bonding part can be locally and~~
~~efficiently enclosed separably from the surroundings, and the~~
~~local chamber capable of properly varying can vary the shape of~~
~~the enclosed space can be formed interlockingly with the bonding~~
~~operation while maintaining the enclosed state even at the time~~
~~of bonding, a specified mounting can be easily performed by a~~
~~small device.~~ --